A BALLOON OBSERVATION OF THE THERMAL RADIATION FROM THE CIRCUMSOLAR DUST CLOUD IN THE 1983 TOTAL ECLIPSE

T.MAIHARA, K. MIZUTANI, N. HIROMOTO, H. TAKAMI and H. HASEGAWA

Department of Physics, Kyoto University,
Kitashirakawa, Kyoto 606, Japan

ABSTRACT. During the totality on June 11, 1983 in East Java, Indonesia, a near infrared photometric observation of the solar corona was made using a stratospheric balloon, which was successfully launched by a joint team of ISAS, Japan and LAPAN, Indonesia. The surface brightness distributions in four near infrared bands : at 1.25, 1.65, 2.25 and 2.8 μm, have been obtained in the outer coronal region. Noticeable excess emissions superposed on the strong coronal background emission have been recorded in the scan profiles at 1.25 and 1.65 μm, and less conspicuously at 2.25 μm as well, at about 4 $R_\odot$ from the sun. From the observed spectral and spatial characteristics, the excess emission component appears to originate in the thermal radiation from the circumsolar dust ring made of relatively large particles of about 100 μm in radius and with the olivine-like optical properties.

1. INTRODUCTION

One of the methods to study the properties of the interplanetary dusts is to measure the thermal radiation from them in the proximity of the sun. The merit of it is that the spectral feature would represent directly the optical properties reflecting the composition and size of dust particles. It is necessary to make such observations by avoiding the effect of the strong emission of the sun itself. Total eclipse enables this, and thus there have been a few observations, in which an excess emission at 2.2 μm has been detected (MacQueen 1968 ; Peterson 1969, 1971).

In the present observation we tried to measure the near infrared energy spectrum as well as the polarization of the particular emission feature formerly detected at about 4 $R_\odot$ from the sun. We utilized a stratospheric balloon on the occasion of totality on June 11, 1983. The successful ballooning was jointly performed by The Institute of Space and Astronautical Science, Japan and The Indonesian National Institute of Aeronautics and Space, which are described in Isobe et al. (1985) in this volume.

R. H. Giese and P. Lamy (eds.), Properties and Interactions of Interplanetary Dust, 55–58.

2. OBSERVATIONS

The instrument consisted of a 16 cm F/4 cassegrain telescope attached to a four-wavelength band simultaneous photometer, in which four 4-element array detectors of lead-sulfide and a filter/beam splitter system were installed. Effective wavelengths of each band are 1.25, 1.65, 2.25 and 2.8 μm respectively. At the 2.25 μm band, it is capable of measuring linear polarization by the additional optical components (a wire-mesh polarizer and a rotating half wave plate). Each detector subtends a field of view of about 5 arcmin projected in the sky.

Scanning were made, for about 3 minutes during the totality at the floating altitude of 30 km, between 6 $R_\odot$ on the west side of the sun and 14 $R_\odot$ on the east side. The scan paths crossed the ecliptic plane on the west side at ~ 4 $R_\odot$ where the actual data of surface brightness profiles were obtained, and continued slightly south of the ecliptic with an inclination of ~ 70 (cf. Fig.1 of Mizutani et al. 1984, paper I).

3. INFRARED POLARIZATION AND THE F CORONA

As Beard(1984) points out, measurement of infrared polarization of the corona is important to get a knowledge of the size of interplanetary dusts.

We have obtained 2.25 μm polarizations only in the inner region of the corona (Fig.1), and yet they are useful to discriminate between the K and F corona components. It is safely assumed that the polarization originates only in K corona ($P_K \simeq 60\%$; see van de Hulst, 1950), while the F corona can be regarded to be non-polarized in this region ($\lesssim 3\ R_\odot$). Hence the separation of the K corona component is

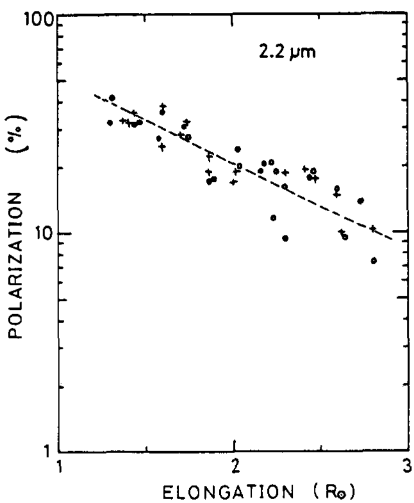

Fig.1 2.25 μm polarization data along the scan path

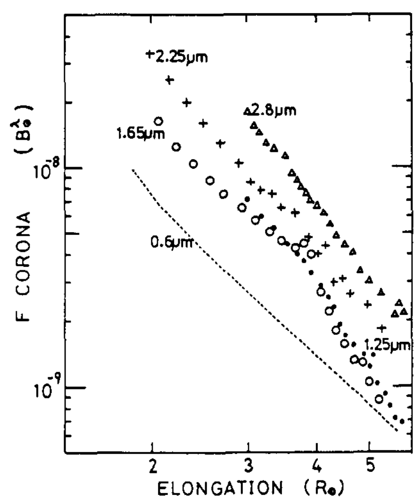

Fig.2 Derived F corona components on the west side of the sun (0.6 μm: Dürst 1982)

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uniquely made. Since the scattering nature of the K corona has no wavelength dependence, it turns out that we have got the K corona brightness at each band. Thus we can extract the F corona profiles as shown in Fig.2.

The ordinate of Fig.2 is the intensity expressed by the unit of mean solar brightness : $B_{\odot}^{\lambda}$. It should be noted that near infrared light is considerably brighter than the 0.6 μm visual light, and besides, the brightness appears to become stronger at longer wavelengths in general.

This is an important information obtained for the first time by the present observation, because by analysing this we can learn the effective size range of dust particles as follows.

A spectrum of the F corona at $3R_{\odot}$, for instance, is plotted in Fig.3. Here we show calculated curves for a model F corona assuming the particle radius a = 1, 10, and 100 μm. In this calculation, we adopt the spatial distribution of $r^{-1.1}$, letting the density equal zero inside 3.8 $R_{\odot}$. From this figure it is obvious that the particles must be as large as 100 μm in radius or even larger.

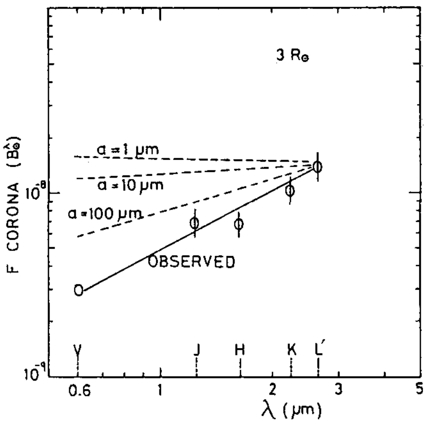

Fig.3 Spectrum of the F corona compared with calculations.

In the course of this calculation one can notice that, when we employ such large particles, the F corona light is largely contributed by dusts located relatively far from the sun. This fact is just consistent with the supposition that the F corona is virtually not polarized. It is also very important to note that the size spectrum in the region smaller than 100 μm in radius must be rather flat, i.e. the index of the power spectrum : γ<2, when expressed as $a^{-\gamma}$.

4. THERMAL EMISSION FROM THE INNERMOST DUST CLOUD

As reported in Paper I (Mizutani et al. 1984), some of the scan profiles of the surface brightness of the corona have demonstrated apparent excess emissions at several wavelength bands. Those features are also discerned in the F coronal profiles in Fig.2.

Is it possible to interprete it as the scattered solar radiation by a dust cloud in an annulus with density enhancement? Remember that the dust contributing to the F coronal emission is as large as 100 μm in radius. If we assume the particles responsible for the excess emission at ∿4 $R_{\odot}$ are in the same size range, it is difficult to expect such appreciable excess by scattering, because the phase functions of scattering in large (∿90°) angles are so small that the density enhancement, if any, of a factor (≲10) could be compensated.

Another aspect is the spectral characteristic of the excess component, which is presented in Fig.4 adding the data of previous observations. This spectral feature is also hard to understand as

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scattered light, but is easily ascribed to the thermal emission with a particular optical properties in the near infrared wavelengths. Thus we have tried to fit the spectrum to olivine particles with large size of, ~100 μm in Paper I. Absorption coefficients of olivine particles with various sizes have been calculated by Röser and Staude (1978).

Although we can get a consistent picture of the general interplanetary dust in terms of the claimed excess emission as well as the infrared F corona, there remains a problem that the derived temperature : 1300K is appreciably lower than the equilibrium temperature 1900K when olivine is assumed. In this connection we may have to presume even larger particles than 100 μm (in that case, the absorption in the 1.25 to 1.65 μm region becomes stronger, thereby the temperature taken here turning out to be higher). It is also possible to conceive a composite particle made up of olivine and other minerals with lower equilibrium temperature.

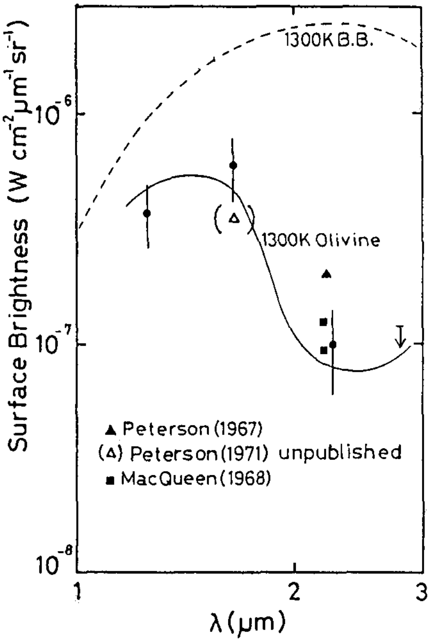

Fig.4 Emission sperctrum the excess component. Data of previous observations are also plotted.

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